

# THE CHANDRA SURVEY OF EXTRAGALACTIC SOURCES IN THE 3CR CATALOG: X-RAY EMISSION FROM NUCLEI, JETS AND HOTSPOTS IN THE CHANDRA ARCHIVAL OBSERVATIONS

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version September 26, 2016: fm

## ABSTRACT

As part of our program to build a complete radio and X-ray database of all the 3CR extragalactic radio sources, we present an analysis of 93 sources for which *Chandra* archival data are available. Most of these sources have been already published. Here we provide a uniform re-analysis and present nuclear X-ray fluxes and X-ray emission associated with radio jet knots and hotspots using both publicly available radio images and new radio images that have been constructed from data available in the VLA archive. For about 1/3 of the sources in the selected sample a comparison between the *Chandra* and the radio observations was not reported in the literature: we find X-ray detections of 2 new radio jet knots and 17 hotspots. We also report the X-ray detection of extended emission from the intergalactic medium of 15 galaxy clusters, two of which were most likely unknown previously.

*Subject headings:* galaxies: active — X-rays: general — radio continuum: galaxies

## 1. INTRODUCTION

The first release of the Third Cambridge catalog (3C), performed at 159 MHz, was published in 1959 (Edge et al. 1959). In 1962 Bennett et al. revised the whole 3C catalog using observations at 178 MHz and this revised version (3CR) was considered a definitive list of the brightest radio sources in the Northern Hemisphere for many years. The flux limit of the 3CR catalog is set to 9 Jy at 178 MHz and it covers the whole Northern Hemisphere above  $-5^\circ$  in Declination. Then, in 1985, Spinrad, Djorgovski, Marr and Aguilar presented the last revised version of the Third Cambridge catalog (3CR) (Bennett 1962) listing 298 extragalactic radio sources (see also Edge et al. 1959; Mackay 1971; Smith et al. 1976; Smith et al. 1980) including new revised positions, redshifts and magnitudes having 91% of the sources out of the Galactic plane (i.e., Galactic latitude  $|b| > 10^\circ$ ). Since then several photometric and spectroscopic surveys have been carried out to obtain multifrequency coverage of the 3CR catalog. All the 3CR sources at redshift  $z < 0.3$  have been already observed with the Hubble Space Telescope (HST) (e.g., Chiaberge et al. 2000; Tremblay et al. 2009) while a near infrared, optical and ultraviolet survey for higher redshift sources is still ongoing. A large fraction of the 3CR radio sources were also targets of the spectroscopic survey carried out with the Telescopio Nazionale Galileo (TNG; e.g., Buttiglione et al. 2009). Radio images with arcsecond reso-

lution for the majority of the 3CR sources are available from the NRAO Very Large Array (VLA) Archive Survey (NVAS)<sup>9</sup> and from the MERLIN archive<sup>10</sup>. As a radio low frequency catalog, the selection criteria for the 3CR are unbiased with respect to X-rays. Since it spans a wide range of redshift and radio power and has a vast multifrequency database of ground and spaced based observations for comparison, it is an ideal sample to investigate properties of active galaxies.

Motivated by the large number of multifrequency observations already available for the 3CR sources, we have undertaken a project to ensure that each 3CR extragalactic source has at least an exploratory/snapshot *Chandra* observation. We have chosen to achieve this goal in a step wise strategy, working out in redshift with modest proposals each cycle to minimize the impact on the *Chandra* schedule. A description of our progress in this endeavor is given in the following sections.

In this paper we present the X-ray analyses of most of the 3CR sources present in the *Chandra* archive which have not already been published by us with our standard procedures: i.e. the snapshot surveys (Massaro et al. 2010; Massaro et al. 2012; Massaro et al. 2013; Massaro et al. 2015) and the 3CR sources in the XJET sample (Massaro et al. 2011). Our main aim is to provide a uniform analysis for all the archival observations. X-ray flux maps were constructed and compared with radio images to search for any X-ray emission associated with radio jet knots, hotspots and lobes. In some cases new radio images have been constructed from archival VLA data for comparison with the X-ray images. We report the measurements of the X-ray nuclear emission for all sources in our sample, but we did not perform a detailed spectral analysis because most of them (i.e.,  $>70\%$ ) have already been reported in the literature (see e.g., Hardcastle et al. 2009; Balmaverde et al. 2012; Wilkes et al. 2013; Kuraszkiewicz et al. 2015).

The paper is organized as follows. A brief historical

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<sup>9</sup> <http://archive.nrao.edu/nvas/>

<sup>10</sup> [http://www.jb.man.ac.uk/cgi-bin/merlin\\_retrieve.pl](http://www.jb.man.ac.uk/cgi-bin/merlin_retrieve.pl)

overview of the *Chandra* observations of the 3CR sources is provided in § 2 while the description of the selected sample is presented in § 3. Data reduction procedures are given in § 4 while results are discussed in § 5. Then, § 6 is devoted to our summary and conclusions. Finally, in the Appendix, we show the X-ray images with radio contours superposed for all the sources analyzed (§ A) and a summary of the *Chandra* observations for the entire sample of 3CR extragalactic sources (§ B).

For numerical results, cgs units are used unless stated otherwise and a flat cosmology was assumed with  $H_0 = 72 \text{ km s}^{-1} \text{ Mpc}^{-1}$ ,  $\Omega_M = 0.27$  and  $\Omega_\Lambda = 0.73$  (Dunkley et al. 2009), to be consistent with our previous analyses (e.g., Massaro et al. 2010; Massaro et al. 2012; Massaro et al. 2013). Spectral indices,  $\alpha$ , are defined by flux density,  $S_\nu \propto \nu^{-\alpha}$ .

## 2. HISTORY OF THE 3CR CHANDRA SURVEY

A large fraction of the X-ray studies of 3CR extragalactic sources observed with *Chandra* is biased towards observations of “favorite” X-ray bright sources or objects with well-known interesting features and/or peculiarities (e.g. sources in the center of bright galaxy clusters) rather than consisting of well defined samples. However to complete the X-ray coverage for the whole 3CR catalog and to obtain a complete and uniform multifrequency database of these extragalactic radio sources, we started, during *Chandra* Cycle 9, an X-ray snapshot survey of the 3CR sources previously unobserved by *Chandra*. Several subsets of the 3CR sample have been observed by other groups (e.g., Wilkes et al. 2013; Kuraszkiewicz et al. 2015).

The 3CR extragalactic catalog includes 298 sources with 248 of them already in the *Chandra* archive. Among the observed ones we have already published 47 sources as part of the XJET project (Massaro et al. 2011)<sup>11</sup> and an additional 98 as part of our 3CR *Chandra* snapshot survey (Massaro et al. 2010; Massaro et al. 2012; Massaro et al. 2013; Massaro et al. 2015). Here we publish an additional 93 sources from the *Chandra* archive. It is worth noting that of the remaining 50 sources unobserved by *Chandra*, half are unidentified, i.e. lacking of an assigned optical counterpart and thus unclassified. Table 1 gives the references for the 145 sources we have already processed and published.

According to the redshift estimates reported in the 3CR catalog, the *Chandra* archive now contains all the 3CR sources up to  $z = 0.5$  (i.e., 150 sources), with the only exceptions of: 3CR 27, at  $z = 0.184$ , 3CR 69 at  $z = 0.458$  (Hiltner & Roeser 1991) and 3CR 93 at  $z = 0.357$ , as confirmed by Ho & MinJin (2009).

In this paper of the series we present the X-ray analysis of the 3CR sources that were not described either in our XJET database (Massaro et al. 2011) or in the analyses of the *Chandra* snapshot survey (Massaro et al. 2010, 2012, 2013). This will permit us to obtain a uniform database of the 3CR X-ray and radio observations.

## 3. SAMPLE SELECTION FOR 3CR ARCHIVAL OBSERVATIONS

In the present paper we uniformly analyzed 93 3CR sources observed by *Chandra* that were not reported in our previous investigations. We excluded from the present archival analysis seven 3CR sources which have been extensively

discussed in the literature and which have an accumulated exposure time greater than 80 ks each. The excluded sources are: 3CR 66A (e.g., Abdo et al. 2011), 3CR 71 (alias NGC 1068; e.g., Brinkman et al. 2002), 3CR 84 (alias NGC1275 or Perseus A; e.g., Fabian et al. 2003), 3CR 186 (Siemiginowska et al. 2010), 3CR 231 (alias M82; e.g., Griffiths et al. 2000), 3CR 317 (alias Abell 2052; e.g., Blanton et al. 2009) and 3CR 348 (alias Hercules A; e.g., Nulsen et al. 2005). In addition we also did not select for our analysis the following three cases: 3CR 236, 3CR 326, 3CR 386 since the PI of these observations is currently working on them (M. Birkinshaw, priv. comm.).

In Table 2 and 3, we list all the selected 93 sources, their coordinates, redshift estimates, luminosity distance, the *Chandra* observation ID number, exposure times and observing dates. In the same tables we also list the references where the *Chandra* observations were analyzed/presented.

## 4. DATA REDUCTION AND DATA ANALYSIS

The radio and X-ray data reduction and analysis procedures adopted in the present analysis were extensively described in Massaro et al. (2012, 2013) and references therein. Here we report only the basic details.

### 4.1. Radio observations

Radio observations presented in this paper were retrieved from publicly available websites of M. J. Hardcastle and C. C. Cheung, from the NVAS (National Radio Astronomy Observatory VLA Archive Survey), from NED (NASA Extragalactic Database), from the DRAGN website, or were constructed from data available in the VLA archives. Summary of the archival data used is reported in Table 4. In the latter case, to produce our final images, we calibrated the data with standard procedures using AIPS (Astronomical Image Processing System), edited the visibilities, and carried out a few self-calibration cycles. Image parameters for each figure are given in the Appendix.

### 4.2. X-ray observations

The data reduction was performed following the standard procedure described in the *Chandra* Interactive Analysis of Observations (CIAO) threads<sup>12</sup>, using CIAO v4.6 and the *Chandra* Calibration Database (CALDB) version 4.6.2. Level 2 event files were generated using the *acis\_process\_events* task and events were filtered for grades 0,2,3,4,6. Lightcurves were also extracted for every dataset thus confirming the absence of to verify the absence of high background intervals. Astrometric registration was achieved by aligning the nuclear X-ray position with that of the radio (see e.g. Massaro et al. 2010; Massaro et al. 2011).

Three different flux maps were created in the energy ranges: 0.5 – 1 keV (soft), 1 – 2 keV (medium), 2 – 7 keV (hard). Flux maps, as implemented in CIAO, are corrected for exposure time and effective area and our implementation used monochromatic exposure maps. Each band is assigned a nominal energy; in our case the nominal energies are 0.75, 1.4, and 4 keV for the soft, medium and hard band, respectively and the exposure maps are constructed for these nominal values. Since the natural units of X-ray flux maps are counts/sec/cm<sup>2</sup> we converted them to cgs units by multiplying each event by the nominal energy of its band, thereby assuming that every

<sup>11</sup> <http://hea-www.cfa.harvard.edu/XJET/>

<sup>12</sup> <http://cxc.harvard.edu/ciao/guides/index.html>

TABLE 1  
SUMMARY OF THE 3CR SOURCES ANALYZED IN OUR PREVIOUS INVESTIGATIONS

Program	Cycle	Proposal Number	Number of sources	Redshift range	Reference
3CR snapshot survey	9	09700745	30*	$z < 0.3$	Massaro et al. (2010)
XJET <sup>†</sup>	—	—	47	—	Massaro et al. (2011)
3CR snapshot survey	12	12700211	26	$z < 0.3$	Massaro et al. (2012)
3CR snapshot survey	13	13700190	19	$z < 0.5$	Massaro et al. (2013)
3CR snapshot survey	15	15700111	23	$z < 1.0$	Massaro et al. (2015)
Archival project <sup>†</sup>	—	—	93	—	This work

\* The AO9 sample includes 3CR 346 that was re-observed in Cycle 12 because during Cycle 9 its *Chandra* observation was affected by high background (see Massaro et al. 2010, for details).

<sup>†</sup> The redshift ranges for both the archival and the XJET samples are unbounded w.r.t. selection.

event in the band has the same energy. However, when we perform our photometry, we make the necessary correction to recover the observed  $\text{erg/cm}^2/\text{s}$ . The use of the “nominal energy” is only to get the correct units. The total energy for **any** particular region is recovered by applying a correction factor of  $E(\text{average})/E(\text{nominal})$  to the photometric measurement to derive  $E(\text{average})$ , the actual values were measured. This correction ranged from a few to 15%.

To measure observed fluxes for the nuclear emission as well as for any feature, a region of size and shape appropriate to the observed X-ray emission was chosen. Two background regions, each with the same shape and size, were chosen so as to avoid emission from other parts of the source and to sample both sides of jet features or two areas close to hotspots. The flux in any particular band for any particular region was measured using funtools<sup>13</sup> (see also Massaro et al. 2011).

A one  $\sigma$  error is calculated based on the usual  $\sqrt{\text{number} - \text{of} - \text{counts}}$  in the source and background regions. Fluxes reported here are not corrected for the Galactic absorption. X-ray fluxes measured for the cores are reported in Table 5 and 6 while those for the radio jet knots and hotspots detected are given in Table 7.

At the focal point, the *Chandra* mirrors produce an image of a point source with a FWHM of the order  $0''.7$ . Since the native ACIS pixel size is  $0''.492$ , the data are undersampled. To recover the resolution inherent in the telescope, we normally regrid our images with a binning factor of 1/2, 1/4, or 1/8 of the native ACIS pixel size. The choice of binning factor was dictated by the angular size of the radio source and by the number of counts in source components. The fact that the telescope dithers during each observation, together with the fact that real numbers rather than integers are used throughout for event location, permits us to achieve adequate Nyquist sampling of the point spread function (PSF). For sources of large angular extent 1/2 or no regridding was used (see also Massaro et al. 2012; Massaro et al. 2013, for more details).

## 5. RESULTS

X-ray emission was clearly detected for 85 out of 93 nuclei in our sample. For 3CR 441 we did not perform X-ray photometry since the number of counts measured within a circular region of  $2''$  centered on the radio position is consistent with the background. For an additional four sources, namely: 3CR 99, 3CR 220.3, 3CR 256 and 3CR 368 we measured too few X-ray counts to define a discrete nucleus in the *Chandra* image. In the three sources 3CR 28, 3CR 288, and 3CR 310 we could not measure the X-ray flux because the extended emission from the cluster washes out the discrete nuclear emission. For all the other sources the nuclear X-ray fluxes in the three bands (see § 4.2) together with their X-ray luminosities are reported in Tables 5 and 6.

<sup>13</sup> <http://www.cfa.harvard.edu/~john/funtools>

A detailed spectral analysis for the bright cores is beyond the scope of this paper since a large fraction of the sources were extensively analyzed in the literature. As done in our previous investigations, in Tables 5 and 6 we also report an ‘extended emission’ parameter computed as the ratio of the net counts in the  $r = 2''$  circle to the net counts in the  $r = 10''$  circular region surrounding the core of each 3CR source (i.e., Ext. Ratio “Extent Ratio”). Values significantly less than 0.9 indicate the presence of extended emission around the nuclear component (e.g., Massaro et al. 2010; Massaro et al. 2013).

We detected and report here, the X-ray emission of 8 radio jet knots in 7 sources and 17 hotspots in 13 objects while no emission arising from lobes was found. To the best of our knowledge, 2 of our jet knot detections (3CR 78 and 3CR 245) and all the hotspots have not previously been reported in the literature.

X-ray fluxes for radio jet knots and hotspots found in the 3CR sample are reported in Table 7, where the classification of each component is also provided. The significance of all detections is above  $5\sigma$ , with the exception of the northern hotspot in 3CR 470 (i.e., n14.4) that corresponds to a  $\sim 1\sigma$  detection. These significances have been computed assuming a Poisson distribution for the background as done in Massaro et al. (2013).

In our sample there are also 15 sources, members of galaxy clusters, for which extended X-ray emission is clearly visible, 13 of these were previously known as cluster related X-ray sources while the remaining 2, namely 3CR 427.1 and 3CR 449, are reported here for the first time to the best of our knowledge. For each galaxy cluster in our sample we present the basic parameters in Table 8: the associated 3CR radio source, the alternative X-ray or optical name if it was a known galaxy cluster, the size of the X-ray emission estimated as the radius of a circular region surrounding its emission, both in arcseconds and in kpc, together with the number of counts within the same area. A dedicated analysis of the 3CR sources in galaxy clusters, listed in the *Chandra* snapshot survey, will be presented in a future paper.

All the X-ray images for the selected sample are presented in the Appendix.

## 6. SUMMARY AND CONCLUSIONS

We have described the combined radio-X-ray analyses of 93 3CR radio sources for which *Chandra* observations requested by others for many different reasons, were already present in the archive. The main objectives of the present analysis are: (1) to present a uniform X-ray and radio database for the 3CR catalog, (2) to search for possible detections of X-ray emission from radio jet knots, hotspots and lobes and (3) to look for new galaxy cluster detections surrounding the 3CR radio sources.

In order to perform the radio-X-ray comparison we reduced archival radio observations for 6 sources. We focused on the



comparison between the radio and the X-ray emission from extended components such as radio jet knots, hotspots, and lobes. We discovered 2 new radio jet knots and 17 hotspots emitting in the X-rays. Flux maps for all the X-ray observations were constructed and we provided photometric results for all the extended components detected.

All the radio knots and hotspots have been classified on the basis of the radio morphology of their parent source, adopting the definition suggested by Leahy et al. (1997) for the hotspots, i.e., brightness peaks which are neither the core nor a part of the jet, usually lying where the jet terminates, and considering all other discrete brightness enhancements as jet knots.

The following conventions for labeling the extended structures detected in the X-rays was adopted. We indicated with the letter ‘k’ the jet knots and with ‘h’ the hotspots; then the name of each component is a combination of one letter (indicating the cardinal direction of the radio feature with respect to the nucleus) and one number (indicating the distance from the core in arcsec) as described in Massaro et al. (2011). We also reported the presence of 15 X-ray galaxy clusters associated with the selected 3CR source, 13 already known in the X-rays and 2, namely 3CR 427.1 and 3CR 449, reported here for the first time to the best of our knowledge.

In the Appendix we present X-ray images with radio contours for all the 93 sources analyzed in this paper (§ A) and in (§ B) we give the *Chandra* status of the observations for all extragalactic 3CR sources.

We thank the anonymous referee for useful comments that led to improvements in the paper. We are grateful to M. Hardcastle and C. C. Cheung for providing several radio images of the 3CR sources while the remaining ones were downloaded from the NVAS<sup>14</sup> (NRAO VLA Archive Survey), NED<sup>15</sup> (Nasa Extragalactic Database) and from the DRAGN web-page<sup>16</sup>. This investigation is supported by the NASA grants GO1-12125A, GO2-13115X, and GO4-15097X. G.R.T acknowledges support by the European Community’s Seventh Framework Programme (FP7/2007- 2013/) under grant agreement No. 229517. This work was also supported by contributions of European Union, Valle D’Aosta Region and the Italian Minister for Work and Welfare. The National Radio Astronomy Observatory is operated by Associated Universities, Inc., under contract with the National Science Foundation. This research has made use of data obtained from the High-Energy Astrophysics Science Archive Research Center (HEASARC) provided by NASA’s Goddard Space Flight Center; the SIMBAD database operated at CDS, Strasbourg, France; the NASA/IPAC Extragalactic Database (NED) operated by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration. TOPCAT<sup>17</sup> (Taylor 2005) for the preparation and manipulation of the tabular data and the images. SAOImage DS9 were used extensively in this work for the preparation and manipulation of the images. SAOImage DS9 was developed by the Smithsonian Astrophysical Observatory.

Facilities: VLA, MERLIN, CXO (ACIS)

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<sup>14</sup> <http://archive.nrao.edu/nvas/>

<sup>15</sup> <http://ned.ipac.caltech.edu/>

<sup>16</sup> <http://www.jb.man.ac.uk/atlas/>

<sup>17</sup> <http://www.star.bris.ac.uk/~mbt/topcat/>

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TABLE 2  
SOURCE LIST OF THE ARCHIVAL *Chandra* 3CR RADIO SOURCES

3CR name	R.A. (J2000) (hh mm ss)	Dec. (J2000) (dd mm ss)	z	kpc scale (kpc/arcsec)	$D_L$ (Mpc)	<i>Chandra</i> Obs. and proposal IDs	Obs. Date yyyy-mm-dd	Data Mode	Exposure (ksec)	References
2.0	00:06:22.6	-00:04:24.6	1.0374	7.999	6849.63	5617 (06700116)	2005-07-28	ACIS-S FAINT	16.93	Miller et al. (2011)
13.0	00:34:14.500	+39:24:17.00	1.351	8.357	9528.43	9241 (09700482)	2008-06-01	ACIS-S FAINT	19.53	Wilkes et al. (2013)
14.0	00:36:06.447	+18:37:59.08	1.469	8.412	10578.07	9242 (09700482)	2008-05-29	ACIS-S FAINT	3.00	Wilkes et al. (2013)
22.0	00:50:56.222	+51:12:03.26	0.936	7.792	6024.20	14994 (14700660)	2013-06-05	ACIS-S FAINT	9.35	Kuraszkiewicz et al. (2015)
28.0	00:55:50.6	+26:24:36.7	0.1953	3.162	931.87	3233 (03800625)	2002-10-07	ACIS-I VFAINT	49.72	McCarthy et al. (2004), Donato et al. (2004)
35.0	01:12:02.288	+49:28:35.62	0.067	1.250	293.48	10240 (10700504)	2009-03-08	ACIS-I VFAINT	25.63	Isobe et al. (2011)
40.0	01:26:00.616	-01:20:42.44	0.018	0.356	75.99	7823 (08700576)	2007-09-07	ACIS-S VFAINT	64.82	Sun et al. (2009)
43.0	01:29:59.776	+23:38:19.85	1.459	8.409	10488.44	9324 (09700482)	2008-06-17	ACIS-S FAINT	3.04	Wilkes et al. (2013)
48.0	01:37:41.301	+33:09:35.27	0.367	4.991	1923.58	3097 (03700781)	2002-03-06	ACIS-S VFAINT	9.22	Worrall et al. (2004)
49.0	01:41:09.159	+13:53:28.33	0.621	6.687	3837.59	14995 (14700660)	2013-08-31	ACIS-S FAINT	9.45	Kuraszkiewicz et al. (2015)
65.0	02:23:43.1	+40:00:51.9	1.176	8.203	8011.89	9243 (09700482)	2008-06-30	ACIS-S FAINT	20.91	Wilkes et al. (2013)
68.1	02:32:28.8	+34:23:45.9	1.238	8.269	8543.36	9244 (09700482)	2008-02-10	ACIS-S FAINT	3.05	Wilkes et al. (2013)
68.2	02:34:23.8	+31:34:17.0	1.575	8.435	11537.52	9245 (09700482)	2008-03-06	ACIS-S FAINT	19.88	Wilkes et al. (2013)
75.0	02:57:41.570	+06:01:36.92	0.0232	0.456	98.33	4181 (04800347)	2003-09-19	ACIS-I VFAINT	21.49	Balmaverde et al. (2006), Hudson et al. (2006)
78.0	03:08:26.222	+04:06:39.26	0.0287	0.560	122.12	4157 (04700407)	2004-06-28	ACIS-S VFAINT	50.86	Harwood & Hardcastle (2012)
88.0	03:27:54.171	+02:33:42.24	0.0302	0.588	128.66	11977 (11800517)	2009-10-06	ACIS-S VFAINT	49.62	Sun et al. (2009)
98.0	03:58:54.431	+10:26:02.72	0.0305	0.594	129.97	10234 (10700504)	2008-12-24	ACIS-I VFAINT	31.71	Hodges-Kluck et al. (2010)
99.0	04:01:07.6	+00:36:33.1	0.426	5.474	2296.01	5680 (06700612)	2005-11-28	ACIS-S FAINT	5.07	
129.1	04:50:06.645	+45:03:05.91	0.0222	0.436	94.03	2219 (02800530)	2001-01-09	ACIS-I FAINT	9.63	Krawczynski et al. (2002)
136.1	05:16:03.275	+24:58:25.68	0.064	1.198	279.75	9326 (09700606)	2008-01-11	ACIS-S FAINT	9.91	Balmaverde et al. (2012)
138.0	05:21:09.906	+16:38:22.16	0.759	7.273	4641.94	14996 (14700660)	2013-03-22	ACIS-S FAINT	2.00	Kuraszkiewicz et al. (2015)
147.0	05:42:36.127	+49:51:07.19	0.545	6.276	3271.83	14997 (14700660)	2013-08-26	ACIS-S FAINT	2.00	Kuraszkiewicz et al. (2015)
172.0	07:02:08.305	+25:13:53.52	0.519	6.119	3083.34	14998 (14700660)	2013-09-05	ACIS-S FAINT	9.95	Kuraszkiewicz et al. (2015)
175.0	07:13:02.422	+11:46:16.25	0.77	7.312	4725.35	14999 (14700660)	2013-02-21	ACIS-S FAINT	2.00	Kuraszkiewicz et al. (2015)
175.1	07:14:04.695	+14:36:22.57	0.92	7.754	5896.15	15000 (14700660)	2013-02-10	ACIS-S FAINT	9.94	Kuraszkiewicz et al. (2015)
181.0	07:28:10.216	+14:37:36.60	1.382	8.375	9802.28	9246 (09700482)	2009-02-12	ACIS-S FAINT	3.02	Wilkes et al. (2013)
184.0	07:39:24.4	+70:23:10.0	0.994	7.917	6493.56	3226 (03800590)	2002-09-22	ACIS-S VFAINT	18.89	Belsole et al. (2004), Hardcastle et al. (2004)
190.0	08:01:33.552	+14:14:42.83	1.1956	8.225	8179.15	9247 (09700482)	2007-12-31	ACIS-S FAINT	3.06	Wilkes et al. (2013)
191.0	08:04:47.968	+10:15:23.72	1.956	8.375	15096.31	5626 (06700234)	2005-12-14	ACIS-S VFAINT	19.77	Erlund et al. (2006)
192.0	08:05:35.005	+24:09:50.36	0.0597	1.123	260.18	9270 (09700606)	2007-12-18	ACIS-S FAINT	10.02	Hodges-Kluck et al. (2010)
196.0	08:13:36.058	+48:13:02.66	0.871	7.627	5507.36	15001 (14700660)	2013-03-23	ACIS-S FAINT	2.00	Kuraszkiewicz et al. (2015)
200.0	08:27:25.384	+29:18:45.01	0.458	5.711	2504.16	838 (01700549)	2000-10-06	ACIS-S FAINT	14.66	Hardcastle et al. (2004)
204.0	08:37:45.003	+65:13:35.34	1.112	8.119	7470.55	9248 (09700482)	2008-01-13	ACIS-S FAINT	3.05	Wilkes et al. (2013)
205.0	08:39:06.534	+57:54:17.09	1.534	8.429	11164.65	9249 (09700482)	2008-01-26	ACIS-S FAINT	9.67	Wilkes et al. (2013)
208.0	08:53:08.608	+13:52:54.85	1.1115	8.118	7466.35	9250 (09700482)	2008-01-08	ACIS-S FAINT	3.01	Wilkes et al. (2013)
210.0	08:58:10.0	+27:50:54.9	1.169	8.194	7952.27	5821 (06800802)	2004-12-25	ACIS-S VFAINT	20.57	Gilmour et al. (2009)
215.0	09:06:31.874	+16:46:11.81	0.4121	5.366	2206.92	3054 (03700563)	2003-01-02	ACIS-S FAINT	33.80	Hardcastle et al. (2004)
216.0	09:09:33.498	+42:53:46.51	0.6699	6.916	3978.18	15002 (14700660)	2013-02-25	ACIS-S FAINT	2.00	Kuraszkiewicz et al. (2015)
220.1	09:32:40.025	+79:06:30.14	0.61	6.632	3545.74	839 (01700549)	1999-12-29	ACIS-S FAINT	18.92	Worrall et al. (2001)
220.3	09:39:23.4	+83:15:26.2	0.68	6.961	4052.36	14992 (14700660)	2013-01-21	ACIS-S FAINT	9.94	Haas et al. (2014)
226.0	09:44:16.522	+09:46:17.07	0.8177	7.471	5091.20	15003 (14700660)	2013-10-07	ACIS-S FAINT	9.94	Kuraszkiewicz et al. (2015)
228.0	09:50:10.794	+14:20:00.68	0.5524	6.319	3141.17	2095 (02700363)	2001-06-03	ACIS-S FAINT	13.78	Belsole et al. (2006)
241.0	10:21:54.6	+21:59:31.2	1.617	8.438	11921.71	9251 (09700482)	2008-03-13	ACIS-S FAINT	18.93	Wilkes et al. (2013)
245.0	10:42:44.609	+12:03:31.15	1.0279	7.982	6771.29	2136 (02700500)	2001-02-12	ACIS-S FAINT	10.40	Gambill et al. (2003)
249.1	11:04:13.842	+76:58:58.17	0.3115	4.474	1587.34	3986 (04700368)	2003-07-02	ACIS-I VFAINT	24.04	Stockton et al. (2006)
252.0	11:11:32.995	+35:40:41.50	1.1	8.102	7370.04	9252 (09700482)	2008-03-11	ACIS-S FAINT	19.45	Wilkes et al. (2013)

Col. (1): The 3CR name. Col. (2): Right ascension and Declination (equinox J2000) of the radio position used to perform the registration (see § 4 for details). We reported here the original 3CR position (Spinrad et al. 1985) of the sources for which the radio core was not clearly detected. Col. (3): Redshift  $z$ . We also verified in the literature (e.g., NED and/or SIMBAD databases) if new  $z$  values were reported after the release of the 3CR catalog. Col. (4): The angular to linear scale factor in arcseconds. Cosmological parameters used to compute it are reported in § 1. Col. (5): Luminosity Distance in Mpc. Cosmological parameters used to compute it are reported in § 1. Col. (6): *Chandra* observation identification number. Proposal identification number is also reported in parenthesis. Col. (7): *Chandra* observation date. Col. (8): Data mode indicates how the *Chandra* ACIS detector was configured for the observation analyzed. Col. (9): The total exposure. Col. (10): The reference for the *Chandra* observation.

TABLE 3  
SOURCE LIST OF THE ARCHIVAL *Chandra* 3CR RADIO SOURCES

3CR name	R.A. (J2000) (hh mm ss)	Dec. (J2000) (dd mm ss)	z	kpc scale (kpc/arcsec)	$D_L$ (Mpc)	<i>Chandra</i> Obs. and proposal IDs	Obs. Date yyyy-mm-dd	Data Mode	Exposure (ksec)	References
256.0	11:20:43.02	+23:27:55.2	1.819	8.417	13798.51	1660 (02800089)	2001-04-23	ACIS-I VFAINT	71.25	Vikhlinin et al. (2002)
263.1	11:43:25.094	+22:06:56.10	0.824	7.490	5140.19	15004 (14700660)	2013-03-20	ACIS-S FAINT	9.94	Kuraszkiewicz et al. (2015)
266.0	11:45:43.30	+49:46:08.0	1.275	8.302	8863.60	9253 (09700482)	2008-02-16	ACIS-S FAINT	18.23	Wilkes et al. (2013)
267.0	11:49:56.506	+12:47:18.83	1.14	8.158	7706.55	9254 (09700482)	2008-07-07	ACIS-S FAINT	19.18	Wilkes et al. (2013)
268.1	12:00:24.482	+73:00:45.81	0.97	7.868	6298.40	15005 (14700660)	2013-07-08	ACIS-S FAINT	9.94	Kuraszkiewicz et al. (2015)
268.3	12:06:24.89	+64:13:37.9	0.3717	5.032	1952.68	10382 (10700678)	2009-07-29	ACIS-S VFAINT	42.53	
268.4	12:09:13.610	+43:39:20.89	1.4022	8.385	9981.44	9325 (09700482)	2009-02-23	ACIS-S FAINT	3.02	Wilkes et al. (2013)
270.1	12:20:33.881	+33:43:11.99	1.5284	8.428	11113.88	9255 (09700482)	2008-02-16	ACIS-S FAINT	9.67	Wilkes et al. (2012)
277.1	12:52:26.353	+56:34:19.58	0.3198	4.556	1636.83	3102 (03700781)	2002-10-27	ACIS-S VFAINT	14.01	Siemiginowska et al. (2008)
277.3	12:54:12.010	+27:37:33.86	0.0853	1.559	378.60	11391 (11700216)	2010-03-03	ACIS-S VFAINT	24.80	Balmaverde et al. (2012)
285.0	13:21:17.868	+42:35:14.91	0.0794	1.461	351.00	6911 (07701073)	2006-03-18	ACIS-S VFAINT	39.62	Hardcastle et al. (2006)
286.0	13:31:08.292	+30:30:32.95	0.8499	7.760	5341.81	15006 (14700660)	2013-02-26	ACIS-S FAINT	2.00	Kuraszkiewicz et al. (2015)
287.0	13:30:37.689	+25:09:10.96	1.055	7.567	6995.09	3103 (03700781)	2002-01-06	ACIS-S VFAINT	36.21	Siemiginowska et al. (2008)
288.0	13:38:49.9	+38:51:09.5	0.246	3.777	1209.42	9257 (09700482)	2008-04-13	ACIS-S VFAINT	39.64	Hardcastle et al. (2009), Lal et al. (2010)
289.0	13:45:26.251	+49:46:32.47	0.9674	7.862	6643.17	15007 (14700660)	2013-07-28	ACIS-S FAINT	9.70	Kuraszkiewicz et al. (2015)
298.0	14:19:08.18	+06:28:34.8	1.4381	8.401	10301.34	3104 (03700781)	2002-03-01	ACIS-S VFAINT	17.88	Siemiginowska et al. (2008)
299.0	14:21:05.631	+41:44:48.68	0.367	4.991	1923.58	12019 (10700678)	2009-11-08	ACIS-S VFAINT	39.53	
309.1	14:59:07.58	+71:40:19.9	0.905	7.717	5776.46	3105 (03700781)	2002-01-28	ACIS-S VFAINT	16.95	Belsole et al. (2006)
310.0	15:04:57.12	+26:00:58.5	0.0538	1.019	233.38	11845 (11700016)	2010-04-09	ACIS-S FAINT	57.58	Kraft et al. (2012)
318.0	15:20:05.484	+20:16:05.75	1.574	8.435	11528.39	9256 (09700482)	2008-05-05	ACIS-S FAINT	9.78	Wilkes et al. (2013)
318.1	15:21:51.9	+07:42:31.9	0.0453	0.867	195.26	900 (01800303)	2000-04-03	ACIS-I VFAINT	57.32	Mazzotta et al. (2002)
324.0	15:49:48.811	+21:25:38.34	1.2063	8.237	8270.74	326 (01600145)	2000-06-25	ACIS-S VFAINT	42.18	Boschin (2002)
325.0	15:49:58.421	+62:41:21.57	1.135	8.151	7664.22	6267 (05700521)	2005-04-14	ACIS-S VFAINT	29.65	Salvati et al. (2008)
334.0	16:20:21.819	+17:36:23.90	0.5551	6.335	3159.91	2097 (02700363)	2001-08-22	ACIS-S FAINT	32.47	Hardcastle et al. (2004)
336.0	16:24:39.090	+23:45:12.23	0.9265	7.769	5948.01	15008 (14700660)	2013-03-03	ACIS-S FAINT	2.00	Kuraszkiewicz et al. (2015)
337.0	16:28:52.569	+44:19:06.58	0.635	6.755	3724.80	15009 (14700660)	2013-10-05	ACIS-S FAINT	9.95	Kuraszkiewicz et al. (2015)
338.0	16:28:38.240	+39:33:04.14	0.0304	0.592	129.53	10748 (10800906)	2009-11-19	ACIS-I VFAINT	40.58	Kirkpatrick et al. (2011), Nulsen et al. (2013)
340.0	16:29:36.591	+23:20:12.83	0.7754	7.331	4766.4	15010 (14700660)	2013-10-20	ACIS-S FAINT	9.95	Kuraszkiewicz et al. (2015)
343.0	16:34:33.809	+62:45:35.89	0.988	7.905	6444.64	15011 (14700660)	2013-04-28	ACIS-S FAINT	9.94	Kuraszkiewicz et al. (2015)
343.1	16:38:28.203	+62:34:44.29	0.75	7.240	4573.74	15012 (14700660)	2013-02-25	ACIS-S FAINT	9.94	Kuraszkiewicz et al. (2015)
352.0	17:10:44.138	+46:01:28.47	0.8067	7.436	5006.3	15013 (14700660)	2013-10-10	ACIS-S FAINT	9.95	Kuraszkiewicz et al. (2015)
356.0	17:24:19.041	+50:57:40.14	1.079	8.069	7194.59	9257 (09700482)	2008-01-20	ACIS-S FAINT	19.87	Wilkes et al. (2013)
368.0	18:05:06.3	+11:01:32.0	1.131	8.146	7630.44	9258 (09700482)	2008-06-01	ACIS-S FAINT	19.91	Wilkes et al. (2013)
382.0	18:35:03.387	+32:41:46.85	0.0579	1.092	251.98	6151 (05701042)	2004-10-30	ACIS-S FAINT	63.87	Gliozzi et al. (2007)
388.0	18:44:02.374	+45:33:29.56	0.0917	1.663	408.83	5295 (05700009)	2004-01-29	ACIS-I VFAINT	30.71	Kraft et al. (2006)
401.0	19:40:25.039	+60:41:36.05	0.2011	3.236	962.99	4370 (03700685)	2002-09-21	ACIS-S FAINT	24.85	Reynolds et al. (2005)
427.1	21:04:06.966	+76:33:10.28	0.572	6.430	3277.55	2194 (02700664)	2002-01-27	ACIS-S FAINT	39.45	Hardcastle et al. (2004)
432.0	21:22:46.327	+17:04:37.96	1.785	8.424	13479.35	5624 (06700234)	2005-01-07	ACIS-S VFAINT	19.78	Erlund et al. (2006)
433.0	21:23:44.582	+25:04:27.63	0.1016	1.823	456.17	7881 (08700989)	2007-08-28	ACIS-S VFAINT	37.17	Miller & Brandt (2009)
437.0	21:47:25.265	+15:20:32.03	1.48	8.415	10677.05	9259 (09700482)	2008-01-07	ACIS-S FAINT	19.88	Wilkes et al. (2013)
438.0	21:55:52.269	+38:00:28.33	0.29	4.257	1460.96	12879 (12800244)	2011-01-28	ACIS-S VFAINT	72.04	Hardcastle et al. (2004)
441.0	22:06:04.90	+29:29:20.0	0.708	7.078	4259.10	15656 (14700660)	2013-06-26	ACIS-S FAINT	6.98	Kuraszkiewicz et al. (2015)
442.0	22:14:46.894	+13:50:27.13	0.0263	0.515	111.71	6392 (06700371)	2005-10-07	ACIS-I VFAINT	32.69	Worrall et al. (2007), Hardcastle et al. (2007)
449.0	22:31:20.582	+39:21:29.53	0.0171	0.338	72.12	13123 (11800387)	2010-09-20	ACIS-S VFAINT	59.92	Lal et al. (2013)
455.0	22:55:03.91	+13:13:35.0	0.543	6.264	3249.99	15014 (14700660)	2013-08-13	ACIS-S FAINT	9.95	Kuraszkiewicz et al. (2015)
469.1	23:55:23.034	+79:55:18.28	1.336	8.348	9396.53	9260 (09700482)	2009-05-24	ACIS-S FAINT	19.91	Wilkes et al. (2013)
470.0	23:58:35.910	+44:04:45.51	1.653	8.439	12252.68	9261 (09700482)	2008-03-03	ACIS-S FAINT	19.91	Wilkes et al. (2013)

Col. (1): The 3CR name. Col. (2): Right ascension and Declination (equinox J2000) of the radio position used to perform the registration (see § 4 for details). We reported here the original 3CR position (Spinrad et al. 1985) of the sources for which the radio core was not clearly detected. Col. (3): Redshift  $z$ . We also verified in the literature (e.g., NED and/or SIMBAD databases) if new  $z$  values were reported after the release of the 3CR catalog. Col. (4): The angular to linear scale factor in arcseconds. Cosmological parameters used to compute it are reported in § 1. Col. (5): Luminosity Distance in Mpc. Cosmological parameters used to compute it are reported in § 1. Col. (6): *Chandra* observation identification number. Proposal identification number is also reported in parenthesis. Col. (7): *Chandra* observation date. Col. (8): Data mode indicates how the *Chandra* ACIS detector was configured for the observation analyzed. Col. (9): The total exposure. Col. (10): The reference for the *Chandra* observation.

TABLE 4  
SUMMARY OF RADIO OBSERVATIONS.

Name	NRAO Project ID.	Freq (GHz)	Time on source (sec)	HPBW (arcsec x arcsec)
3CR 210	AO230	1.42	1200	$1.66 \times 1.62$
3CR 256	AM224	4.76	180	$1.72 \times 1.35$
3CR 267	AL330	8.44	1620	$0.81 \times 0.74$
3CR 277.1	AV231	22.46	360	$0.097 \times 0.080$
3CR 437	AV164	4.86	1500	$1.22 \times 1.17$
3CR 470	AL330	8.46	1780	$1.54 \times 1.27$

Col. (1): The 3CR name. Col. (2): The identification number of the observer program, as reported in the header of the raw u,v data downloaded from the VLA archive (see <https://archive.nrao.edu/archive/nraodashelpj.html> for more details). Col. (3): The frequency at which the radio observations were performed. Col. (4): The total exposure in seconds. Col. (5): The half-power beam width (HPBW) of the reduced radio images.

TABLE 5  
X-RAY EMISSION FROM RADIO CORES.

3CR name	Net Counts	Ext. Ratio	$F_{0.5-1\text{ keV}}^*$ (cgs)	$F_{1-2\text{ keV}}^*$ (cgs)	$F_{2-7\text{ keV}}^*$ (cgs)	$F_{0.5-7\text{ keV}}^*$ (cgs)	$L_X$ ( $10^{44}\text{ erg s}^{-1}$ )
2.0	839 (29)	0.34 (0.02)	77.79 (7.04)	125.34 (6.16)	291.05 (17.06)	494.18 (19.45)	31.07 (1.22)
13.0	14 (4)	0.00 (-)	0.79 (0.4)	0.88 (0.4)	3.02 (1.51)	4.69 (1.61)	0.57 (0.2)
14.0	228 (15)	0.94 (0.09)	59.38 (8.38)	129.09 (12.48)	314.41 (37.58)	502.88 (40.47)	75.48 (6.07)
22.0	64 (8)	0.83 (0.14)	0.0 (0.0)	4.82 (1.64)	95.56 (13.0)	100.38 (13.11)	4.9 (0.64)
35.0	12 (3)	0.61 (0.24)	0.0 (0.0)	1.14 (0.47)	2.93 (1.19)	4.07 (1.28)	0.0005 (0.0002)
40.0	2443 (49)	0.54 (0.02)	80.69 (2.21)	35.59 (1.45)	95.95 (4.95)	212.24 (5.61)	0.00146 (0.00004)
43.0	162 (13)	0.98 (0.11)	42.9 (6.78)	87.82 (10.28)	216.29 (30.59)	347.0 (32.97)	52.17 (4.96)
48.0 <sup>+</sup>	5814 (76)	0.96 (0.02)	699.0 (14.02)	808.37 (17.05)	1514.14 (46.08)	3021.51 (51.09)	15.0 (0.25)
49.0	156 (12)	0.96 (0.11)	0.31 (0.7)	23.32 (3.33)	162.79 (15.66)	186.42 (16.03)	3.28 (0.28)
65.0	196 (14)	0.05 (0.02)	0.89 (0.4)	13.46 (1.6)	77.54 (7.09)	91.9 (7.28)	7.91 (0.63)
68.1	41 (6)	0.9 (0.19)	4.85 (2.42)	18.1 (4.84)	115.99 (24.18)	138.93 (24.78)	13.6 (2.43)
68.2	9 (3)	0.28 (0.12)	0.21 (0.21)	0.37 (0.26)	5.08 (2.07)	5.66 (2.1)	1.01 (0.37)
75.0	219 (15)	0.79 (0.07)	23.62 (2.87)	14.86 (1.73)	57.96 (6.81)	96.44 (7.59)	0.0013 (0.0001)
78.0 <sup>+</sup>	20856 (144)	0.92 (0.01)	432.13 (5.1)	647.73 (6.62)	1004.17 (15.55)	2084.03 (17.65)	0.0396 (0.0003)
88.0	659 (26)	0.6	3.23 (0.61) (0.03)	18.44 (1.24)	109.08 (5.59)	130.75 (5.76)	0.0029 (0.0001)
98.0	1245 (35)	0.93 (0.04)	6.06 (1.24)	9.53 (1.19)	682.98 (20.18)	698.57 (20.26)	0.0153 (0.0004)
129.1	14 (4)	0.22 (0.06)	0.87 (0.87)	4.45 (1.51)	0.7 (2.27)	6.03 (2.86)	7.02e-5 (3.33e-5)
136.1	6 (2)	0.17 (0.17)	0.53 (0.53)	0.54 (0.38)	5.57 (3.22)	6.64 (3.28)	0.0007 (0.0003)
138.0 <sup>+</sup>	385 (20)	0.96 (0.07)	116.59 (16.7)	330.91 (25.32)	1232.66 (96.62)	1680.17 (101.27)	48.56 (2.93)
147.0	150 (12)	0.99 (0.11)	44.12 (10.7)	160.22 (17.8)	341.21 (47.89)	545.54 (52.2)	6.99 (0.67)
172.0	26 (5)	0.70 (0.18)	0.0 (0.0)	1.81 (0.91)	43.38 (9.09)	45.19 (9.13)	0.51 (0.1)
175.0 <sup>+</sup>	355 (19)	0.95 (0.07)	160.43 (19.35)	308.97 (24.35)	831.95 (75.32)	1301.35 (81.49)	38.73 (2.43)
175.1	86 (9)	0.89 (0.13)	4.91 (1.55)	16.32 (2.56)	43.87 (7.66)	65.1 (8.23)	3.04 (0.38)
181.0	166 (13)	0.96 (0.10)	55.43 (7.86)	91.52 (10.51)	181.96 (29.52)	328.91 (32.3)	42.39 (4.16)
184.0	38 (6)	0.75 (0.16)	0.72 (0.32)	0.86 (0.38)	21.92 (4.07)	23.5 (4.1)	1.33 (0.23)
190.0	165 (13)	0.96 (0.10)	49.91 (7.72)	96.73 (10.62)	150.5 (24.1)	297.14 (27.44)	26.74 (2.47)
191.0	715 (27)	0.95 (0.05)	32.66 (2.25)	57.13 (3.17)	121.57 (9.04)	211.37 (9.84)	64.62 (3.01)
192.0	46 (7)	0.72 (0.15)	1.77 (0.72)	3.15 (1.13)	52.72 (9.83)	57.64 (9.92)	0.0511 (0.0009)
196.0	87 (9)	0.90 (0.13)	10.4 (5.2)	87.35 (13.75)	297.91 (45.97)	395.67 (48.26)	16.1 (1.96)
200.0	202 (14)	0.81 (0.08)	11.55 (1.36)	19.61 (2.1)	32.8 (5.19)	63.97 (5.76)	0.54 (0.05)
204.0 <sup>+</sup>	343 (19)	0.96 (0.07)	114.07 (11.21)	190.04 (14.9)	301.77 (35.56)	605.89 (40.15)	45.36 (3.01)
205.0 <sup>+</sup>	969 (31)	0.95 (0.04)	83.36 (5.42)	160.57 (7.62)	381.82 (22.71)	625.75 (24.56)	104.63 (4.11)
208.0	260 (16)	0.98 (0.09)	81.55 (9.68)	135.04 (12.54)	314.41 (36.8)	531.0 (40.06)	39.57 (2.99)
210.0	28 (5)	0.31 (0.08)	0.07 (0.16)	1.7 (0.54)	15.04 (3.67)	16.82 (3.72)	1.43 (0.32)
215.0 <sup>+</sup>	11445 (107)	0.96 (0.01)	306.26 (5.02)	480.6 (6.97)	1140.72 (21.07)	1927.58 (22.75)	12.51 (0.15)
216.0 <sup>+</sup>	244 (16)	0.97 (0.09)	134.19 (17.93)	203.98 (19.72)	553.56 (62.16)	891.73 (67.63)	18.94 (1.44)
220.1	1072 (33)	0.79 (0.03)	49.97 (2.44)	70.94 (3.55)	162.57 (10.71)	283.48 (11.55)	4.98 (0.2)
226.0	54 (7)	0.83 (0.15)	0.63 (0.63)	4.33 (1.46)	64.42 (9.97)	69.38 (10.09)	2.41 (0.35)
228.0	338 (18)	0.93 (0.07)	19.88 (1.9)	34.71 (2.88)	79.68 (8.92)	134.28 (9.57)	1.77 (0.13)
241.0	146 (12)	1.00 (0.12)	1.75 (0.58)	13.25 (1.61)	48.95 (5.89)	63.96 (6.14)	12.19 (1.17)
245.0	1835 (43)	0.94 (0.03)	154.08 (6.21)	264.18 (9.48)	608.4 (29.24)	1026.67 (31.37)	63.31 (1.93)
249.1 <sup>+</sup>	4367 (66)	0.96 (0.02)	252.12 (8.42)	322.33 (7.58)	1041.37 (25.72)	1615.82 (28.11)	5.44 (0.09)
252.0	86 (9)	0.64 (0.09)	0.19 (0.19)	4.25 (0.94)	51.24 (6.52)	55.67 (6.59)	4.08 (0.48)

Col. (1): The 3CR name. Col. (2): The net counts. The  $1\sigma$  uncertainties, reported in parenthesis, are computed assuming a Poisson distribution. Col. (3): The Ext. Ratio defined as the ratio of the net counts in the  $r = 2''$  circle to the net counts in the  $r = 10''$  circular region surrounding the core of each 3CR source. The  $1\sigma$  uncertainties, reported in parenthesis, are computed assuming a Poisson distribution. Col. (4): Measured X-ray flux between 0.5 and 1 keV. Col. (5): Measured X-ray flux between 1 and 2 keV. Col. (6): Measured X-ray flux between 2 and 7 keV. Col. (7): Measured X-ray flux between 0.5 and 7 keV. Col. (8): X-ray luminosity in the range 0.5 to 7 keV with the  $1\sigma$  uncertainties given in parenthesis.

Note:

(\*) Fluxes are given in units of  $10^{-15}\text{ erg cm}^{-2}\text{ s}^{-1}$  and  $1\sigma$  uncertainties are given in parenthesis. The uncertainties on the flux measurements were computed as described in § 4.2

(†) Sources having count rates above the threshold of 0.1 counts per frame for which the X-ray flux measurements is affected by pileup (see Massaro et al. 2013, and references therein for additional details).



TABLE 6  
X-RAY EMISSION FROM RADIO CORES.

3CR name	Net Counts	Ext. Ratio	$F_{0.5-1\text{ keV}}^*$ (cgs)	$F_{1-2\text{ keV}}^*$ (cgs)	$F_{2-7\text{ keV}}^*$ (cgs)	$F_{0.5-7\text{ keV}}^*$ (cgs)	$L_X$ ( $10^{44}\text{ erg s}^{-1}$ )
263.1	430 (21)	0.96 (0.07)	52.7 (5.0)	70.61 (5.15)	180.43 (15.76)	303.74 (17.32)	10.77 (0.61)
266.0	19 (4)	1.07 (0.42)	0.5 (0.29)	0.81 (0.41)	9.29 (2.68)	10.61 (2.73)	1.12 (0.29)
267.0	166 (13)	0.89 (0.10)	0.88 (0.4)	10.0 (1.41)	81.65 (7.83)	92.53 (7.97)	7.37 (0.63)
268.1	46 (7)	0.94 (0.20)	0.4 (0.4)	1.21 (0.88)	60.37 (9.31)	61.98 (9.36)	3.32 (0.5)
268.3	398 (20)	0.98 (0.07)	1.3 (0.3)	4.57 (0.66)	117.52 (6.54)	123.4 (6.58)	0.63 (0.03)
268.4	282 (17)	0.98 (0.08)	78.15 (9.55)	145.82 (12.99)	375.22 (40.28)	599.19 (43.39)	79.76 (5.78)
270.1 <sup>+</sup>	691 (26)	0.94 (0.05)	69.18 (4.89)	120.54 (6.72)	219.62 (17.11)	409.34 (19.02)	66.79 (3.1)
277.1	2287 (48)	0.95 (0.03)	167.79 (5.7)	225.01 (7.37)	468.66 (21.27)	861.45 (23.22)	3.1 (0.08)
277.3	229 (15)	0.81 (0.07)	1.38 (0.5)	4.28 (0.83)	140.84 (10.18)	146.5 (10.22)	0.028 (0.002)
285.0	457 (21)	0.87 (0.06)	0.34 (0.2)	1.44 (0.38)	216.95 (10.38)	218.73 (10.39)	0.036 (0.002)
286.0	117 (11)	0.96 (0.12)	87.64 (14.08)	100.04 (13.74)	158.45 (31.69)	346.14 (37.3)	13.21 (1.42)
287.0	3424 (59)	0.97 (0.02)	95.29 (2.62)	129.05 (3.45)	245.11 (9.29)	469.45 (10.25)	30.81 (0.67)
289.0	52 (7)	0.75 (0.13)	0.0 (0.0)	3.01 (1.37)	78.49 (11.63)	81.5 (11.71)	4.3 (0.62)
298.0 <sup>+</sup>	9993 (100)	0.97 (0.01)	493.95 (8.59)	821.4 (12.42)	1660.05 (34.61)	2975.41 (37.76)	424.2 (5.38)
299.0	81 (9)	0.77 (0.12)	0.9 (0.28)	0.53 (0.22)	30.86 (3.81)	32.29 (3.82)	0.16 (0.02)
309.1 <sup>+</sup>	5254 (72)	0.97 (0.02)	259.9 (6.33)	423.95 (9.19)	1145.75 (30.3)	1829.6 (32.29)	81.67 (1.44)
318.0	256 (16)	0.96 (0.08)	23.6 (2.87)	43.99 (4.0)	89.4 (11.0)	156.99 (12.05)	4.43 (0.34)
318.1	106 (10)	0.071 (0.004)	2.79 (0.99)	4.82 (1.09)	3.97 (2.37)	11.57 (2.79)	0.0006 (0.0002)
324.0	40 (6)	0.61 (0.14)	0.64 (0.18)	0.92 (0.27)	5.48 (1.49)	7.05 (1.52)	0.65 (0.14)
325.0	365 (19)	0.86 (0.06)	2.6 (0.57)	19.23 (1.58)	93.96 (6.8)	115.79 (7.01)	4.56 (0.28)
334.0 <sup>+</sup>	7178 (85)	0.96 (0.02)	203.45 (3.98)	292.96 (5.48)	684.21 (16.74)	1180.62 (18.06)	15.81 (0.24)
336.0 <sup>+</sup>	191 (14)	0.95 (0.10)	98.63 (15.04)	184.79 (19.01)	343.29 (47.61)	626.71 (53.42)	29.78 (2.54)
337.0	9 (3)	0.53 (0.23)	0.0 (0.0)	1.1 (0.79)	11.33 (4.28)	12.43 (4.35)	0.23 (0.08)
338.0	246 (16)	0.092 (0.005)	16.48 (2.67)	13.33 (2.08)	12.17 (3.91)	41.97 (5.17)	0.0009 (0.0001)
340.0	86 (9)	0.92 (0.14)	1.46 (0.86)	11.56 (2.32)	84.78 (11.25)	97.8 (11.52)	2.98 (0.35)
343.0	18 (4)	0.76 (0.25)	2.88 (1.18)	2.46 (1.02)	6.61 (2.96)	11.95 (3.34)	0.67 (0.19)
343.1	47 (7)	1.04 (0.22)	3.02 (1.23)	9.88 (2.06)	25.2 (6.15)	38.09 (6.6)	1.07 (0.19)
352.0	129 (11)	0.88 (0.11)	2.57 (1.31)	22.66 (3.21)	95.99 (11.47)	121.22 (11.98)	4.05 (0.4)
356.0	24 (5)	0.38 (0.09)	0.35 (0.33)	0.73 (0.43)	13.24 (3.12)	14.32 (3.17)	0.99 (0.22)
382.0 <sup>+</sup>	14052 (119)	0.86 (0.01)	72.82 (1.91)	174.65 (3.14)	2363.24 (24.23)	2610.71 (24.5)	0.215 (0.002)
388.0	271 (16)	0.28 (0.02)	20.53 (2.4)	19.15 (1.82)	19.28 (3.63)	58.96 (4.71)	0.013 (0.001)
401.0	229 (15)	0.34 (0.02)	9.48 (1.12)	12.35 (1.44)	26.96 (3.96)	48.79 (4.36)	0.06 (0.01)
427.1	18 (4)	0.22 (0.05)	0.24 (0.16)	0.24 (0.24)	4.85 (1.56)	5.33 (1.59)	0.08 (0.02)
432.0	730 (27)	0.93 (0.05)	34.32 (2.33)	57.96 (3.23)	120.42 (8.81)	212.7 (9.67)	53.29 (2.42)
433.0 <sup>+</sup>	2724 (52)	0.92 (0.02)	2.69 (0.55)	13.24 (1.25)	1139.84 (22.48)	1155.78 (22.52)	0.32 (0.01)
437.0	7 (3)	0.43 (0.19)	0.2 (0.2)	0.37 (0.26)	4.1 (2.09)	4.67 (2.12)	0.71 (0.32)
438.0	162 (13)	0.1 (0.01)	1.2 (0.38)	3.62 (0.62)	14.83 (2.22)	19.65 (2.34)	0.06 (0.01)
442.0	181 (13)	0.58 (0.06)	3.08 (0.99)	13.86 (1.53)	41.91 (4.58)	58.85 (4.93)	0.00096 (8e-5)
449.0	558 (24)	0.54 (0.03)	12.81 (0.97)	13.41 (0.95)	31.81 (2.77)	58.02 (3.08)	0.0004 (2e-5)
455.0	150 (12)	0.96 (0.11)	13.61 (2.62)	29.18 (3.39)	64.09 (9.16)	106.88 (10.11)	1.35 (0.13)
469.1	77 (9)	0.72 (0.11)	0.32 (0.23)	2.66 (0.78)	47.29 (6.02)	50.27 (6.07)	5.95 (0.72)
470.0	54 (7)	0.76 (0.14)	0.0 (0.0)	1.46 (0.61)	35.08 (5.06)	36.54 (5.1)	7.36 (1.03)

Col. (1): The 3CR name. Col. (2): The net counts. The  $1\sigma$  uncertainties, reported in parenthesis, are computed assuming a Poisson distribution. Col. (3): The Ext. Ratio defined as the ratio of the net counts in the  $r = 2''$  circle to the net counts in the  $r = 10''$  circular region surrounding the core of each 3CR source. The  $1\sigma$  uncertainties, reported in parenthesis, are computed assuming a Poisson distribution. Col. (4): Measured X-ray flux between 0.5 and 1 keV. Col. (5): Measured X-ray flux between 1 and 2 keV. Col. (6): Measured X-ray flux between 2 and 7 keV. Col. (7): Measured X-ray flux between 0.5 and 7 keV. Col. (8): X-ray luminosity in the range 0.5 to 7 keV with the  $1\sigma$  uncertainties given in parenthesis.

Note:

(\*) Fluxes are given in units of  $10^{-15}\text{ erg cm}^{-2}\text{ s}^{-1}$  and  $1\sigma$  uncertainties are given in parenthesis. The uncertainties on the flux measurements were computed as described in § 4.2

(\*) Sources having count rates above the threshold of 0.1 counts per frame for which the X-ray flux measurements is affected by pileup (see Massaro et al. 2013, and references therein for additional details).

TABLE 7  
X-RAY EMISSION FROM RADIO EXTENDED STRUCTURES (I.E., KNOTS AND HOTSPOTS).

3CR name	Component	class	Counts	$F_{0.5-1\text{ keV}}^*$ (cgs)	$F_{1-2\text{ keV}}^*$ (cgs)	$F_{2-7\text{ keV}}^*$ (cgs)	$F_{0.5-7\text{ keV}}^*$ (cgs)	$L_X$ ( $10^{42}\text{ erg s}^{-1}$ )
13.0	n16.5	h	5 (0.375)	0.58 (0.34)	0.16 (0.16)	0.76 (0.76)	1.5 (0.85)	18.27 (10.35)
65.0	e6.6	h	4 (0.375)	0.23 (0.23)	0.0 (0.0)	1.01 (1.01)	1.24 (1.04)	10.68 (8.95)
65.0	w6.7	h	7 (0.25)	0.46 (0.27)	0.4 (0.29)	0.72 (0.72)	1.58 (0.82)	13.6 (7.06)
68.2	n11.5	h	5 (0.25)	0.0 (0.0)	1.02 (0.46)	0.0 (0.0)	1.02 (0.46)	18.21 (8.21)
78.0	e1.6	k	1001 (406)	15.58 (1.29)	22.46 (1.61)	39.19 (3.84)	77.22 (4.36)	0.15 (0.01)
88.0	e109	k	33 (6.75)	0.71 (0.26)	0.77 (0.25)	0.72 (1.02)	2.2 (1.08)	0.005 (0.002)
181.0	e4.5	h	3 (0.125)	1.21 (1.21)	0.94 (0.94)	2.7 (2.7)	4.86 (3.11)	62.64 (40.08)
191.0	s1.9 <sup>+</sup>	k	18 (0.125)	1.01 (0.42)	0.86 (0.44)	3.19 (1.6)	5.07 (1.71)	154.99 (52.28)
200.0	s9.3 <sup>+</sup>	k	6 (0.125)	0.0 (0.0)	0.7 (0.41)	1.49 (1.49)	2.19 (1.54)	1.84 (1.3)
210.0	s7.6	h	5 (0.125)	0.28 (0.2)	0.28 (0.28)	0.65 (0.65)	1.21 (0.74)	10.26 (6.28)
215.0	e2.6 <sup>+</sup>	k	26 (0.25)	0.31 (0.28)	0.14 (0.36)	1.06 (1.12)	1.5 (1.21)	0.97 (0.79)
228.0	n24.8	h	6 (0.125)	0.0 (0.0)	1.03 (0.46)	0.59 (0.59)	1.62 (0.75)	2.14 (0.99)
228.0	s21.4	h	16 (0.125)	1.35 (0.48)	2.25 (0.8)	0.0 (0.0)	3.6 (0.93)	4.76 (1.23)
245.0	w1.5 <sup>+</sup>	k	26 (0.125)	1.98 (0.76)	0.76 (1.07)	1.16 (2.32)	3.9 (2.66)	24.05 (16.4)
268.1	w25	h	25 (0.125)	0.71 (0.5)	5.95 (1.49)	11.08 (4.19)	17.74 (4.47)	95.13 (23.97)
299.0	e2.7	h	22 (0.375)	0.94 (0.28)	1.0 (0.32)	0.45 (0.45)	2.39 (0.62)	1.19 (0.31)
324.0	e5.8	h	9 (0.5)	0.18 (0.1)	0.23 (0.12)	0.42 (0.42)	0.84 (0.45)	7.7 (4.13)
325.0	e6.8	h	10 (0.375)	0.34 (0.19)	0.34 (0.25)	0.95 (0.68)	1.63 (0.75)	6.43 (2.96)
325.0	w9.2	h	7 (0.125)	0.1 (0.1)	0.21 (0.21)	1.73 (0.86)	2.03 (0.89)	8.0 (3.51)
334.0	s2.7 <sup>+</sup>	k	30 (0.625)	1.0 (0.32)	0.94 (0.4)	0.25 (0.81)	2.19 (0.95)	2.93 (1.27)
334.0	s17.5 <sup>+</sup>	k	26 (5.75)	0.76 (0.27)	1.1 (0.37)	1.99 (1.82)	3.85 (1.87)	5.15 (2.5)
437.0	n19	h	12 (0.625)	0.48 (0.28)	0.74 (0.37)	3.32 (1.66)	4.54 (1.72)	69.43 (26.3)
437.0	s17	h	7 (0.5)	0.32 (0.23)	0.22 (0.22)	1.28 (1.19)	1.83 (1.24)	27.98 (18.96)
470.0	n14.4	h	1 (0.75)	0.0 (0.0)	0.0 (0.0)	0.29 (0.66)	0.29 (0.66)	5.84 (13.29)
470.0	s9.4	h	10 (0.625)	0.76 (0.38)	0.33 (0.24)	2.0 (1.42)	3.1 (1.49)	62.43 (30.01)

Col. (1): The 3CR name. Col. (2): The component name chosen according to the definition reported in § 4.2. Col. (3): The component class: "h" = hotspot - "k" = knot. Col. (4): The number of counts column gives the total counts in the photometric circle together with the average of the 8 background regions, in parentheses; both for the 0.5 to 7 keV band. Col. (5): Measured X-ray flux between 0.5 and 1 keV. Col. (6): Measured X-ray flux between 1 and 2 keV. Col. (7): Measured X-ray flux between 2 and 7 keV. Col. (8): Measured X-ray flux between 0.5 and 7 keV. Col. (9): X-ray luminosity in the range 0.5 to 7 keV with the  $1\sigma$  uncertainties given in parenthesis.

Note:

(<sup>+</sup>) Source components for which the X-ray emission was already reported in the literature.

(\*) Fluxes are given in units of  $10^{-15}\text{ erg cm}^{-2}\text{ s}^{-1}$  and  $1\sigma$  uncertainties are given in parenthesis. The uncertainties on the flux measurements were computed as described in § 4.2

TABLE 8  
X-RAY GALAXY CLUSTERS.

3CR name	Other name	$z$	R (arcsec)	R (kpc)	Total Counts
28.0	Abell 115	0.195	200	632	31450
40.0	Abell 194	0.0181	170	60	23855
75.0	Abell 400	0.023	500	228	57400
88.0	1RXS J032755.0+023403	0.0302	120	70	6610
220.1	1RXS J093245.5+790636	0.61	25	166	1722
288.0	1RXS J133849.3+385110	0.246	60	680	5324
310.0	SDSS J150457.12+260058.4	0.0538	180	183	28309
318.1	Abell 2063B	0.0453	500	433	272770
338.0	Abell 2199	0.03035	500	296	504360
388.0	1RXS J184402.1+453332	0.0917	240	400	15416
401.0	1RXS J194024.4+604136	0.055	90	292	3200
427.1		0.572	40	257	467
438.0	1RXS J215553.4+380021	0.290	210	894	66288
442.0	1RXS J221451.0+135040	0.0263	300	155	15506
449.0		0.017	240	81	42378

Col. (1): The 3CR name. Col. (2): Alternative name. Col. (3): The source redshift. Col. (4): Radius in arcseconds. Col. (5): Radius in kpc. Col. (6): The net counts.

TABLE 9  
CAPTIONS

3CR name	Binning Factor (X-rays)	FWHM-smoothing (X-rays)-(arcsec)	Low-contour-level (mJy/beam)	Factor increase	Radio freq. (GHz)	HPBW (arcsec x arcsec)	NRAO Project Code
2 <sup>(1)</sup>	1/4	0.72	6.4	4	1.5	1.2x1.4	AH0171 – (NVAS)
13.0	1/8	0.51	1.0	2	4.9	0.37	AC0200 – (NVAS)
14.0	1/8	0.51	3.0	4	8.5	0.23	AL0280 – (NVAS)
22.0	1/8	0.51	0.125	4	8.5	0.25	AP380 – (MJH)
28.0	1/8	0.65	0.25	4	1.4	1.10	AL272 – (NED)
35.0	1	4.0	4.0	2	1.5	17x14	AW0087 – (NVAS)
40.0	2	8.0	4.0	4	1.6	23x12	AB0022 – (NVAS)
43.0	1/8	0.51	6.0	4	8.3	0.23	AJ0206 – (NVAS)
48.0	1/8	0.36	12.5	4	4.8	0.59x0.47	AW0227 – (NVAS)
49.0	1/8	0.36	4.0	4	4.9	0.41	NEFF – (NED)
65.0	1/8	0.51	4.0	2	1.5	1.28x1.13	PERL – (NVAS)
68.1	1/4	1.0	2.0	2	1.4	1.46x1.33	AW0482 – (NVAS)
68.2	1/4	0.72	1.0	2	4.9	0.53x0.39	AV0164 – (NVAS)
75.0	1	1.7	0.25	4	4.6	4.6x3.8	AE0061 – (NVAS)
78.0 <sup>(2)</sup>	1/8	0.51	2.0	2	1.5	4.3x3.9	AB0376 – (NVAS)
88.0	1/2	1.4	1.0	2	4.9	4.4x4.2	AP0077 – (NVAS)
98.0	1	4.0	0.25	2	8.3	2.0	PERL – (NED)
99.0	1/4	–	–	–	4.8	0.45x0.39	AS302 – (NVAS)
129.1	1/4	1.0	0.125	2	4.8	1.25	AT229 – (NVAS)
136.1	1	3.5	2.0	2	1.6	3.3	POOL – (NVAS)
138.0	1/8	0.51	1.0	4	4.9	0.42	AL0142 – (NVAS)
147.0	1/8	0.36	19.2	4	8.4	0.27	AK403 – (CCC)
172.0	1/4	0.72	0.125	4	8.5	0.90	AP361 – (MJH)
175.0	1/4	0.72	0.5	4	8.5	0.78x0.61	AH0452 – (NVAS)
175.1	1/8	0.36	1.2	4	4.9	0.35	AP380 – (MJH)
181.0	1/8	0.36	1.0	4	4.9	0.37	AH0552 – (NVAS)
184.0	1/8	0.36	16.0	4	8.5	0.36x0.20	AK0403 – (NVAS)
190.0	1/8	0.36	4.0	2	8.5	0.20	AO0105 – (NVAS)
191.0	1/8	0.36	0.3	4	4.7	0.30	AK180 – (CCC)
192.0	1/2	1.4	0.125	4	8.2	0.80	PERL – (NED)
196.0	1/8	0.36	0.5	4	4.9	0.35	AB516 – (MJH)
200.0	1/8	0.65	0.125	4	8.5	0.25	AP331 – (MJH)
204.0	1/8	0.51	0.5	4	8.3	0.78x0.65	AW0249 – (NVAS)
205.0	1/8	0.36	2.0	4	8.3	0.22	AW0330 – (NVAS)
208.0	1/8	0.36	0.125	4	8.4	0.25	AL280 – (CCC)
210.0	1/4	1.3	6.4	4	1.4	1.6	AO230 – (TW)
215.0 <sup>(3)</sup>	1/8	0.36	0.1	4	4.9	0.37	BRID – (MJH)
216.0	1/8	0.36	4.8	4	8.2	0.25	AG357 – (MJH)
220.1	1/8	0.36	0.1	4	8.4	0.25	AP380 – (MJH)
220.3 <sup>(4)</sup>	1/8	0.51	1.0	2	8.4	0.70x0.43	AM0384 – (NVAS)
226.0	1/8	0.51	0.125	4	8.5	0.20	AP380 – (MJH)
228.0	1/8	0.51	0.125	4	8.5	0.23	AP331 – (MJH)
241.0	1/8	0.36	1.2	4	8.4	0.20	AA0149 – (NVAS)
245.0	1/8	0.36	0.5	4	4.9	0.25	AB244 – (CCC)
249.1	1/8	0.36	0.1	4	4.9	0.35	BRID – (MJH)
252.0	1/4	1.0	0.5	4	4.9	1.0	AF0213 – (NVAS)
256.0	1/4	1.0	0.4	4	4.8	1.7x1.4	AM244 – (TW)

Col. (1): The 3CR name. Col. (2): The binning factor of the X-ray image (see § 4.2 for more details). Col. (3): the full width half maximum (FWHM) of the smoothing kernel chosen for the X-ray image. Col. (4): The value of the lowest contour level of the radio map overlaid to the X-ray image. Col. (5): The factor increase of the radio contours. Col. (6): The radio frequency of the radio map used for the comparison with the X-ray image. Col. (7): The half-power beam width (HPBW) of the reduced radio images. Single numbers are reported for circular beam. Col. (8): The identification number of the observer program, as reported in the header of the raw u,v data downloaded from the VLA archive (see <https://archive.nrao.edu/archive/nraodashelpj.html> for more details).

Notes:

- 3CR 2 is 7.9' off axis, so we did not register the X-ray image. The source appears to be extended in the X-rays (~8'') but since it is so far off axis, the apparent size is consistent with the *Chandra* point spread function.
- The white contours at the nucleus are from a Merin observation, performed at 1.4 GHz on May 5<sup>th</sup> 1998, showing the small scale jet. The X-ray images comes from a 1/8th subarray observation and the width of the subarray is smaller than the size of the radio source. The readout streak is evident and lies, unfortunately, along the direction of the jet and the primary axis of the radio emission.
- The prominent readout streak goes right through the jet segment superposed on the E lobe.
- This is a radio galaxy lying at  $z=0.685$  which is lensing a submillimeter galaxy at  $z=2.221$  (Haas et al. 2014).

## APPENDIX

### A: IMAGES OF THE SOURCES

For all the 93 3CR sources in our selected sample, radio morphologies are shown here as contours superposed on the re-gridded/smoothed X-ray events files. The full width half maximum (FWHM) of the Gaussian smoothing function and the binning factor are given in Table 9 and 10. X-ray event files were limited to the 0.5 to 7 keV band and rebinned to change the pixel size with a binning factor 'f' (e.g.  $f=1/4$  produces pixels 4 times smaller than the native ACIS pixel of 0.492"). The labels on the color bar for each X-ray map are in units of counts/pixel. Also included in this table are the radio brightness of the lowest contour, the factor (usually 2 or 4) by which each subsequent contour exceeds the previous one, the frequency of the radio map, and the FWHM of the clean beam. The primary reason figures appear so different from each other is the wide range in angular size of the radio sources.

TABLE 10  
CAPTIONS

3CR name	Binning Factor (X-rays)	FWHM-smoothing (X-rays)-(arcsec)	Low-contour-level (mJy/beam)	Factor increase	Radio freq. (GHz)	HPBW (arcsec x arcsec)	NRAO Project Code
263.1	1/8	0.36	0.25	4	4.9	0.35	DREH – (MJH)
266.0	1/8	0.51	0.4	4	8.4	0.30	AK403 – (CCC)
267 <sup>(5)</sup>	1/8	0.36	0.125	4	8.4	0.85x0.74	AL330 – (TW)
268.1	1/8	0.51	0.25	4	8.5	0.25	AP380 – (MJH)
268.3	1/16	0.33	1.2	4	5.0	0.06	MERLIN2 – (MJH)
268.4	1/8	0.36	2.0	4	8.3	0.72x0.58	AW0249 – (NVAS)
270.1	1/8	0.51	4.8	4	4.9	0.36	AB0522 – (NVAS)
277.1	1/8	0.36	1.0	4	22.5	0.09	AV231 – (TW)
277.3	1/8	0.36	1.0	2	4.9	0.37	CORD – (NVAS)
285.0	1/4	0.72	0.3	4	1.5	1.2	AV0127 – (NVAS)
286.0	1/8	0.36	4.8	4	8.0	0.28x0.23	AG0357 – (NVAS)
287.0	1/16	0.18	10.0	4	8.5	0.24	AK0276 – (NVAS)
288.0	1/4	1.3	0.5	4	4.9	0.6	ED – (NED)
289.0	1/8	0.51	0.4	4	5.0	0.06	MERLIN2 – (MJH)
298.0	1/16	0.18	10.0	4	8.3	0.25	AJ0206 – (NVAS)
299.0	1/8	0.36	1.0	4	1.5	0.13	MERLIN2 – (NED)
309.1	1/8	0.36	4.0	4	14.9	0.17x0.11	TESTT – (NVAS)
310.0	1	7.5	10.0	2	1.5	15x12	AB0182 – (NVAS)
318.0	1/8	0.51	20.0	2	8.5	0.22	AA0149 – (NVAS)
318.1	1/2	2.0	0.3	4	1.4	4.7x4.4	FOMA – (NVAS)
324.0	1/8	0.36	0.125	4	4.9	0.38	AF186 – (CCC)
325.0	1/8	0.51	0.5	4	4.9	0.35	AF213 – (MJH)
334.0	1/8	0.51	0.125	4	4.9	0.35	BRID – (MJH)
336.0	1/4	0.72	0.1	4	4.9	0.35	AB454 – (MJH)
337.0	1/4	1.0	0.25	4	4.9	0.40	AP114 – (MJH)
338.0	1/4	0.72	0.1	2	4.9	1.0	AG269 – (NED)
340.0	1/4	1.0	0.125	4	4.9	0.40	AP380 – (MJH)
343.0	1/4	0.72	19.2	4	4.9	0.42	AB0922 – (NVAS)
343.1	1/8	0.51	32.0	4	1.5	1.3	AM0178 – (NVAS)
352.0	1/8	0.36	0.25	4	4.7	0.35	AG247 – (MJH)
356.0	1/4	0.72	0.75	4	4.9	0.45x0.38	AF0186 – (NVAS)
368.0	1/4	0.72	0.3	4	8.5	0.2	AL0322 – (NVAS)
382.0	1/4	0.72	0.125	4	8.4	0.75	PERL – (NED)
388.0	1/8	0.94	0.25	4	4.9	0.47x0.36	AC0149 – (NVAS)
401.0	1/8	0.51	0.1	4	8.4	0.27	AP315 – (MJH)
(401b)	1/2	3.8	0.1	4	8.4	0.27	AP315 – (MJH)
427.1	1/4	0.72	0.1	4	8.5	0.25	AP331 – (MJH)
(427.1b)	1/2	3.8	0.1	4	8.5	0.25	AP331 – (MJH)
432.0	1/8	0.51	2.0	2	4.9	0.40	AB0454 – (NVAS)
433.0	1/4	0.72	0.1	2	8.5	0.25	AB534 – (MJH)
437.0	1/4	1.0	4.0	4	4.9	1.2	AV164 – (TW)
438.0	1/4	1.3	0.125	4	8.4	0.23	AP315 – (NED)
441.0	1/8	0.51	0.25	4	4.9	0.35	AF213 – (MJH)
442.0	2	5.8	0.5	2	1.4	7.5	PEGG – (NED)
449.0	2	8.1	0.125	4	1.5	4.0	AK319 – (CCC)
(insert)	1/2	1.4	0.25	4	1.7	1.2	PERL – (NVAS)
455.0	1/8	0.51	0.5	4	4.9	0.40	AP331 – (MJH)
469.1	1/4	0.72	2.0	4	4.9	1.7x1.1	AR0123 – (NVAS)
470.0	1/4	0.72	2.0	4	8.4	1.5x1.3	AL330 – (TW)

Col. (1): The 3CR name. Col. (2): The binning factor of the X-ray image (see § 4.2 for more details). Col. (3): the full width half maximum (FWHM) of the smoothing kernel chosen for the X-ray image. Col. (4): The value of the lowest contour level of the radio map overlaid to the X-ray image. Col. (5): The factor increase of the radio contours. Col. (6): The radio frequency of the radio map used for the comparison with the X-ray image. Col. (7): The half-power beam width (HPBW) of the reduced radio images. Single numbers are reported for circular beam. Col. (8): The identification number of the observer program, as reported in the header of the raw u,v data downloaded from the VLA archive (see <https://archive.nrao.edu/archive/nraodashelpj.html> for more details).

Notes:

5. There may be a wcs problem with the coordinates of the radio image of order 1''; so the R.A./Dec. labels could be slightly off.

## B: THE STATUS OF THE *Chandra* X-RAY 3CR OBSERVATIONS

Here we present the current status of the *Chandra* X-ray observations for the entire 3CR catalog. For each 3CR source we indicate the radio-to-optical classification indicating FR I and FR II radio galaxies, according to the Fanaroff & Riley criterion (Fanaroff & Riley 1974); ii) quasars (i.e., QSRs); Seyfert galaxies (Sy) and BL Lac objects (BL). We indicate as “UND” those sources which, lacking optical spectroscopy, remain unidentified. Then the most updated value of the redshift  $z$  is reported together with the luminosity distance  $D_L$  and we also used a “cluster flag” to label sources that belong to a known galaxy cluster. Regarding the X-ray analysis, we report X-ray detections of radio components adopting the following symbols: k = jet knot; h = hotspot; l = lobe and xcl for sources that belong to a galaxy cluster detected in the X-rays. Finally, the “*Chandra* flag” indicates if the source was already observed by *Chandra*.

TABLE 11  
THE CURRENT STATUS OF THE 3CR *Chandra* OBSERVATIONS.

3CR name	class	$z$	$D_L$ Mpc	Cluster flag	X-ray detection	Chandra flag
2.0	QSR	1.037367	7252.26	no		yes
6.1	FR II	0.8404	5577.63	no	h	yes
9.0	QSR	2.019922	16632.24	no	k,l	yes
11.1	UND	?		no		no
13.0	FR II	1.351	10088.93	no	h	yes
14.0	QSR	1.469	11200.31	no		yes
14.1	UND	?		no		no
15.0	FRI	0.073384	341.93	no	k,l	yes
16.0	FR II	0.405	2288.92	no	h,l	yes
17.0	QSR	0.219685	1126.33	no	k	yes
18.0	FR II	0.188	945.54	no		yes
19.0	FR II	0.482	2819.56	yes	h	yes
20.0	FR II	0.174	867.55	no		yes
21.1	UND	?		no		no
22.0	FR II	0.936	6378.57	no		yes
27.0	FR II	0.184	923.17	no		no
28.0	FRI	0.195275	986.54	yes	xcl	yes
29.0	FRI	0.045031	205.48	yes	k	yes
31.0	FRI	0.017005	75.94	yes	k	yes
33.0	FR II	0.0597	275.49	no	h	yes
33.1	FR II	0.180992	906.44	no		yes
33.2	UND	?		no		no
34.0	FR II	0.69	4368.53	no		yes
35.0	FR II	0.067013	310.8	no		yes
36.0	QSR	1.301	9624.8	no		no
40.0	FR II	0.018	80.46	yes	xcl	yes
41.0	FR II	0.795	5205.64	no		yes
42.0	FR II	0.395007	2221.96	no		yes
43.0	QSR	1.459	11105.41	no		yes
44.0	FR II	0.66	4135.83	yes		yes
46.0	FR II	0.4373	2508.42	yes		yes
47.0	QSR	0.425	2424.27	no	h,l	yes
48.0	QSR	0.367	2036.73	no		yes
49.0	FR II	0.621	3837.6	no		yes
52.0	FR II	0.29	1546.9	yes	h	yes
54.0	FR II	0.8274	5470.44	no		yes
55.0	FR II	0.7348	4721.63	no		yes
63.0	FR II	0.175	873.1	no		yes
61.1	FR II	0.18781	944.47	no	h	yes
65.0	FR II	1.176	8483.18	no	h	yes
66.0A	BL	?		yes		yes
66.0B	FRI	0.021258	95.28	yes	k	yes
67.0	FR II	0.3102	1672.55	no		yes
68.1	QSR	1.238	9045.91	no		yes
68.2	FR II	1.575	12216.2	no	h	yes
69.0	FR II	0.458	2651.47	no		no
71.0	Sy	0.003793	16.72	no		yes
75.0	FRI	0.023153	103.9	yes	xcl	yes
76.1	FR II	0.032489	146.82	no		yes
78.0	FRI	0.028653	129.09	no	k	yes

Col. (1): The 3CR name. Col. (2): The radio-to-optical classification of the sources: FRI and FRII refer to the Fanaroff and Riley classification criterion for radio galaxies (Fanaroff & Riley 1974); QSR stands for quasars; Sy for Seyfert galaxies and BL for BL Lac objects. We used the acronym UND for sources that are still unidentified; i.e., lacking of an optical spectroscopic observation. Col. (3): Redshift  $z$ . We also verified in the literature (e.g., NED and/or SIMBAD databases) if new  $z$  values were reported after the release of the 3CR catalog. Col. (4): Luminosity Distance in Mpc. Cosmological parameters used to compute it are reported in § 1. Col. (5): The “cluster flag” indicates if the source is known to be associated with a catalogued cluster of galaxies or if there is significantly extended X-ray emission around the host galaxy; i.e., on scales of 100 kpc or greater. Col. (6): In this column we report if the source has a radio component with an X-ray counterpart. We used the following labels: k = jet knot; h = hotspot; l = lobe. We also indicated xcl if there is a galaxy cluster detected in the X-rays. Col. (7): The “*Chandra* flag” indicates if the source was already observed by *Chandra*.



TABLE 12  
THE CURRENT STATUS OF THE 3CR *Chandra* OBSERVATIONS.

3CR name	class	$z$	$D_L$ Mpc	Cluster flag	X-ray detection	Chandra flag
79.0	FR II	0.255900	1339.62	yes		yes
83.1	FRI	0.025137	112.95	yes	k,xcl	yes
84.0	FRI	0.017559	78.45	yes	xcl	yes
86.0	FR II	?		no		no
88.0	FRI	0.030221	136.32	yes	k,xcl	yes
89.0	FRI	0.1386	675.57	yes	xcl	yes
91.0	UND	?		no		no
93.0	QSR	0.35712	1972.32	no		yes
93.1	FR II	0.243	1262.81	yes		yes
98.0	FR II	0.030454	137.4	no		yes
99.0	Sy	0.426	2431.07	yes		yes
103.0	FR II	0.33	1797.71	no		yes
105.0	FR II	0.089	419.33	no	k,h	yes
107.0	FR II	0.785	5124.51	no		yes
109.0	FR II	0.3056	1643.78	no	h,l	yes
111.0	FR II	0.0485	221.87	no	k,h	yes
114.0	FR II	0.815	5368.77	no		yes
119.0	FR II	1.023	7127.0	no		no
123.0	FR II	0.2177	1114.8	yes	k	yes
124.0	FR II	1.083	7653.06	no		no
125.0	UND	?		no		no
129.0	FRI	0.0208	93.2	yes	k,xcl	yes
129.1	FRI	0.0222	99.56	no		yes
130.0	FRI	0.109	520.76	no		yes
131.0	UND	?		no		no
132.0	FR II	0.214	1093.4	yes		yes
133.0	FR II	0.2775	1470.27	no		yes
134.0	UND	?		no		no
135.0	FR II	0.12738	616.21	yes		yes
136.1	FR II	0.064	296.2	no		yes
137.0	UND	?		no		no
138.0	QSR	0.759	4915.0	no		yes
139.2	FR II	?		no		no
141.0	UND	?		no		no
142.1	FR II	0.4061	2296.3	no		yes
147.0	QSR	0.545	3271.83	no		yes
152.0	UND	?		no		no
153.0	FR II	0.2769	1466.59	yes		yes
154.0	QSR	0.58	3529.84	no		yes
158.0	UND	?		no		no
165.0	FR II	0.2957	1582.19	no		yes
166.0	FR II	0.2449	1274.04	no		yes
169.1	FR II	0.633	3928.69	no		yes
171.0	FR II	0.2384	1235.67	no		yes
172.0	FR II	0.5191	3084.06	no		yes
173.0	QSR	1.035	7231.55	no		no
173.1	FR II	0.2921	1559.87	yes	h,l	yes
175.0	QSR	0.77	5003.31	no		yes
175.1	FR II	0.92	6242.98	no		yes
180.0	FR II	0.22	1128.16	no		yes

TABLE 13  
THE CURRENT STATUS OF THE 3CR *Chandra* OBSERVATIONS.

3CR name	class	$z$	$D_L$ Mpc	Cluster flag	X-ray detection	Chandra flag
181.0	QSR	1.382	10378.89	no	h	yes
184.0	FRII	0.994	6875.53	no		yes
184.1	FRII	0.1182	568.34	yes		yes
186.0	QSR	1.068634	7526.33	yes	xcl	yes
187.0	FRII	0.465	2700.19	no	l	yes
190.0	QSR	1.195649	8660.73	no		yes
191.0	QSR	1.956	15984.33	no	k,l	yes
192.0	FRII	0.059709	275.53	yes		yes
194.0	FRII	1.184	8555.38	no		no
196.0	QSR	0.871	5831.32	no		yes
196.1	FRII	0.198	1002.01	no		yes
197.1	FRII	0.128009	619.51	yes		yes
198.0	FRII	0.081474	381.9	yes		yes
200.0	FRII	0.458	2651.47	yes	k,l	yes
204.0	QSR	1.112	7909.99	no		yes
205.0	QSR	1.534	11821.39	no		yes
207.0	QSR	0.6808	4296.94	no	k,l	yes
208.0	QSR	1.111510	7905.63	no		yes
208.1	QSR	1.02	7100.98	no		no
210.0	FRII	1.169	8420.05	no	h	yes
212.0	QSR	1.048	7345.18	no	h	yes
213.1	FRI	0.19392	978.87	yes	h	yes
215.0	QSR	0.4121	2336.74	no	k,l	yes
217.0	FRII	0.8975	6053.2	no		yes
216.0	QSR	0.669915	4212.31	no		yes
219.0	FRII	0.174732	871.61	yes	k,l	yes
220.1	FRII	0.61	3754.31	yes	xcl	yes
220.2	QSR	1.157429	8316.07	no		no
220.3	FRII	0.68	4290.73	no		yes
222.0	FRI	1.339	9977.24	no		no
223.0	FRII	0.13673	665.6	yes		yes
223.1	FRII	0.107474	512.94	no		yes
225.0A	FRII	1.565	12119.69	no		yes
225.0B	FRII	0.58	3529.84	no		yes
226.0	FRII	0.8177	5390.92	no		yes
227.0	FRII	0.086272	405.71	no	h	yes
228.0	FRII	0.5524	3325.95	no	h	yes
230.0	FRII	1.487	11371.7	no		no
231.0	FRI	0.000677	2.97	no		yes
234.0	FRII	0.184925	928.33	no	h	yes
236.0	FRII	0.1005	477.44	no		yes
237.0	FRII	0.877	5881.45	no		yes
238.0	FRII	1.405	10594.89	no		no
239.0	FRII	1.781	14232.66	no		no
241.0	FRII	1.617	12622.99	no		yes
244.1	FRII	0.428	2444.69	yes		yes
245.0	QSR	1.027872	7169.36	no	k	yes
247.0	FRII	0.7489	4834.0	yes		yes
249.0	QSR	1.554	12013.69	no		no
249.1	QSR	0.3115	1680.71	no		yes
250.0	FRII	?		no		no

TABLE 14  
THE CURRENT STATUS OF THE 3CR *Chandra* OBSERVATIONS.

3CR name	class	$z$	$D_L$ Mpc	Cluster flag	X-ray detection	Chandra flag
252.0	FR II	1.1	7803.57	no		yes
254.0	QSR	0.736619	4736.12	no	h	yes
255.0	QSR	1.355	10126.27	no		no
256.0	FR II	1.819	14610.18	no		yes
257.0	QSR	2.474	21340.67	no		no
258.0	FRI	0.165	818.03	yes		yes
263.0	QSR	0.646	4028.06	no	h	yes
263.1	FR II	0.824	5442.55	no		yes
264.0	FRI	0.021718	97.37	yes	k	yes
265.0	FR II	0.811	5336.02	no	h,l	yes
266.0	FR II	1.275	9384.99	no		yes
267.0	FR II	1.14	8159.88	no		yes
268.1	FR II	0.97	6668.89	no	h	yes
268.2	FR II	0.362	2004.12	yes	h	yes
268.3	FR II	0.37171	2067.61	no		yes
268.4	QSR	1.402200	10568.59	no		yes
270.0	FRI	0.007378	32.63	yes	k	yes
270.1	QSR	1.528432	11767.94	no		yes
272.0	FR II	0.944	6446.64	no		yes
272.1	FRI	0.003392	14.94	yes	k	yes
273.0	QSR	0.158339	781.73	no	k	yes
274.0	FRI	0.004283	18.89	yes	k,xcl	yes
274.1	FR II	0.422	2403.91	no		yes
275.0	FR II	0.48	2805.51	yes		yes
275.1	QSR	0.5551	3345.78	no	k,h,l	yes
277.0	FRI	0.414	2349.59	no		yes
277.1	QSR	0.31978	1732.99	no		yes
277.2	FR II	0.766	4971.13	no		yes
277.3	FR II	0.085336	401.05	no		yes
280.0	FR II	0.996	6892.84	yes	k,h,l	yes
280.1	QSR	1.667065	13110.8	no	l	no
284.0	FR II	0.239754	1243.68	yes		yes
285.0	FR II	0.0794	371.64	no		yes
286.0	QSR	0.849934	5656.31	no		yes
287.0	QSR	1.055	7406.56	no		yes
287.1	FR II	0.215567	1102.45	no	h	yes
288.0	FRI	0.246	1280.56	yes	xcl	yes
288.1	QSR	0.96296	6608.61	no		yes
289.0	FR II	0.9674	6646.6	no		yes
292.0	FR II	0.71	4525.37	no		yes
293.0	FRI	0.045034	205.5	no		yes
293.1	FR II	0.709	4517.5	no		yes
294.0	FR II	1.779	14212.84	yes	h,xcl	yes
295.0	FR II	0.4641	2693.92	yes	h,xcl	yes
296.0	FRI	0.024704	110.97	no	k	yes
297.0	QSR	1.4061	10605.23	no		no
298.0	QSR	1.438120	10907.49	no		yes
299.0	FR II	0.367	2036.73	yes	h	yes
300.0	FR II	0.27	1424.56	no		yes

TABLE 15  
THE CURRENT STATUS OF THE 3CR *Chandra* OBSERVATIONS.

3CR name	class	z	D <sub>L</sub> Mpc	Cluster flag	X-ray detection	Chandra flag
300.1	FR II	1.15885	8328.86	no		no
303.0	FRI	0.141186	689.35	yes	k	yes
303.1	FRI	0.2704	1426.99	no		yes
305.0	FR II	0.041639	189.56	no		yes
305.1	FR II	1.132	8088.23	no		no
306.1	FR II	0.441	2533.89	yes		yes
309.1	QSR	0.905	6116.25	no		yes
310.0	FRI	0.0538	247.11	yes	xcl	yes
314.1	FRI	0.1197	576.16	yes		yes
313.0	FR II	0.461000	2672.37	yes	h,xcl	yes
315.0	FRI	0.1083	517.17	yes		yes
317.0	FRI	0.034457	155.96	yes	xcl	yes
318.0	FR II	1.574	12206.53	yes		yes
318.1	FRI	0.045311	206.8	yes	xcl	yes
319.0	FR II	0.192	968.03	yes		yes
320.0	FR II	0.342	1874.59	yes	xcl	yes
321.0	FR II	0.0961	455.08	no	h	yes
322.0	FR II	1.681	13247.25	no		no
323.0	FR II	0.679	4282.93	no		yes
323.1	QSR	0.2643	1390.12	yes		yes
324.0	FR II	1.2063	8757.25	yes	h	yes
325.0	FR II	1.135	8115.06	no	h	yes
326.0	FR II	0.0895	421.83	no		yes
326.1	FR II	1.825	14669.88	no		no
327.0	FR II	0.1048	499.28	yes	h	yes
327.1	FRI	0.462	2679.32	no	k	yes
330.0	FR II	0.55	3308.36	yes	h	yes
332.0	FR II	0.151019	742.01	yes		yes
334.0	QSR	0.5551	3345.78	no	k,l	yes
336.0	QSR	0.926542	6298.25	no		yes
337.0	FR II	0.635	3943.96	yes		yes
338.0	FRI	0.030354	136.94	yes	xcl	yes
340.0	FR II	0.7754	5046.9	no		yes
341.0	FR II	0.448	2582.06	no	k	yes
343.0	QSR	0.988	6823.74	no		yes
343.1	FR II	0.75	4842.79	no		yes
345.0	QSR	0.5928	3625.15	no	k	yes
346.0	FRI	0.162012	801.73	yes	k	yes
348.0	FRI	0.155	763.55	yes	xcl	yes
349.0	FR II	0.205	1041.79	no	h	yes
351.0	FR II	0.37194	2069.13	no	h	yes
352.0	FR II	0.8067	5300.91	no		yes
353.0	FR II	0.030421	137.25	no	k	yes
356.0	FR II	1.079	7617.8	no		yes
357.0	FR II	0.166148	824.31	yes		yes
368.0	FR II	1.131	8079.29	no		yes
371.0	BL	0.051	233.74	no	k	yes
379.1	FR II	0.256	1340.22	no		yes
380.0	QSR	0.692	4384.16	no	k	yes
381.0	FR II	0.1605	793.51	no		yes
382.0	FR II	0.05787	266.65	no		yes

TABLE 16  
THE CURRENT STATUS OF THE 3CR *Chandra* OBSERVATIONS.

3CR name	class	$z$	$D_L$ Mpc	Cluster flag	X-ray detection	Chandra flag
386.0	FRI	0.016885	75.39	no		yes
388.0	FRII	0.0917	432.88	yes	xcl	yes
389.0	UND	?		no		no
390.0	UND	?		no		no
390.3	FRII	0.0561	258.14	no	k,h	yes
394.0	UND	?		no		no
399.1	FRII	?		no		no
401.0	FRII	0.2011	1019.64	yes	xcl	yes
402.0	FRI	0.025948	116.67	yes	k	yes
403.0	FRII	0.059	272.1	no	k,h	yes
403.1	FRII	0.0554	254.77	yes		yes
405.0	FRII	0.056075	258.01	yes	h,xcl	yes
409.0	FRII	?		no		no
410.0	FRII	0.2485	1295.4	no		yes
411.0	FRII	0.467	2714.14	no		yes
415.2	UND	?		no		no
418.0	QSR	1.686	13296.15	no		no
424.0	FRI	0.126988	614.15	yes		yes
427.1	FRII	0.572	3470.35	yes	l,xcl	yes
428.0	UND	?		no		no
430.0	FRII	0.055545	255.47	yes		yes
431.0	UND	?		no		no
432.0	QSR	1.785	14272.26	no		yes
434.0	FRII	0.322	1746.99	yes		yes
433.0	FRI	0.1016	483.01	no		yes
435.0	FRII	0.471	2742.13	no		yes
436.0	FRII	0.2145	1096.28	no	h	yes
437.0	FRII	1.48	11305.11	no	h	yes
438.0	FRII	0.29	1546.9	yes	xcl	yes
441.0	FRII	0.708	4509.63	no		yes
442.0	FRI	0.0263	118.28	yes	xcl	yes
445.0	FRII	0.055879	257.07	yes	h	yes
449.0	FRI	0.017085	76.3	yes	xcl	yes
452.0	FRII	0.081100	380.05	no	h,l	yes
454.0	QSR	1.757	13995.04	no		no
454.1	FRII	1.841	14829.49	yes		no
454.2	UND	?		no		no
454.3	QSR	0.859	5731.6	no	k	yes
455.0	QSR	0.543	3257.27	no		yes
456.0	FRII	0.233	1203.84	no		yes
458.0	FRII	0.289	1540.74	yes	h	yes
459.0	FRII	0.22012	1128.85	no	l	yes
460.0	FRII	0.268	1412.45	yes		yes
465.0	FRI	0.030221	136.32	yes	k,xcl	yes
468.1	UND	?		no		no
469.1	FRII	1.336	9949.27	no		yes
470.0	FRII	1.653	12973.42	no	h	yes



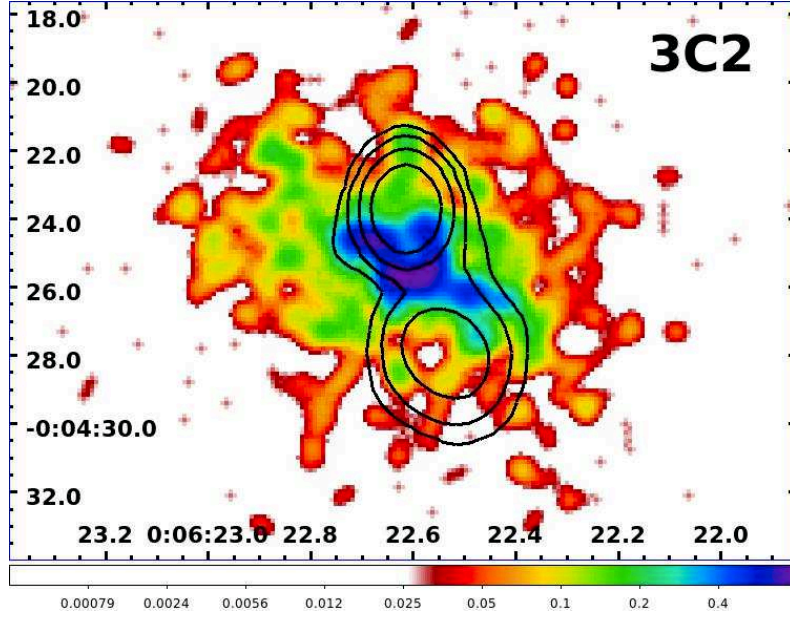


FIG. 1.— The X-ray image corresponding to the Chandra observation (Tables 2 and 3) with contours of radio brightness superposed. The image is re-binned to change the pixel size and is smoothed with a Gaussian function. The underlying color bar shows the X-ray brightness in units of counts per pixel. Radio contours are logarithmically spaced. All relevant parameters for each source are given in Tables 9 and 10.